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THE COMPOSITION AND SEASONAL PERIODICITY OF THE MARINE ESTUARINE CHLOROPHYCEAE IN NEW-HAMPSHIRE

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THE COMPOSITION AND SEASONAL PERIODICITY OF THE MARINE-ESTUARINE CHLOROPHYCEAE IN NEW HAMPSHIRE[1]

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In two previous accounts we have summarized a variety of floristic and phenological data on the Rhodophyceae (Hehre & Mathieson, 1970) and Phaeophyceae (Mathieson & Hehre, 1982) of New Hampshire. A similar compilation for the marine Chlorophyceae is given here, based upon collections and observations made from 1965 to 1980. Monthly or seasonal collections of green algae were made at numerous estuarine and coastal sites throughout New Hampshire (Figs. 1 and 2), with herbarium voucher specimens of each taxon being prepared and deposited in the Albion R. Hodgdon Herbarium of the University of New Hampshire (NHA). The recent nomenclature of South (1976) is followed in most cases. In the present account, a synopsis of 58 chlorophycean taxa is given, with a statement of relative abundance, local distribution (vertical and horizontal), and seasonal occurrence of each taxon.

PHENOLOGY AND DISTRIBUTION

The monthly occurrence of chlorophycean taxa within estuarine-coastal waters in New Hampshire is summarized in Table I. The lowest numbers of taxa were recorded in December and January (i.e., 27 and 24 taxa respectively), while the highest numbers were

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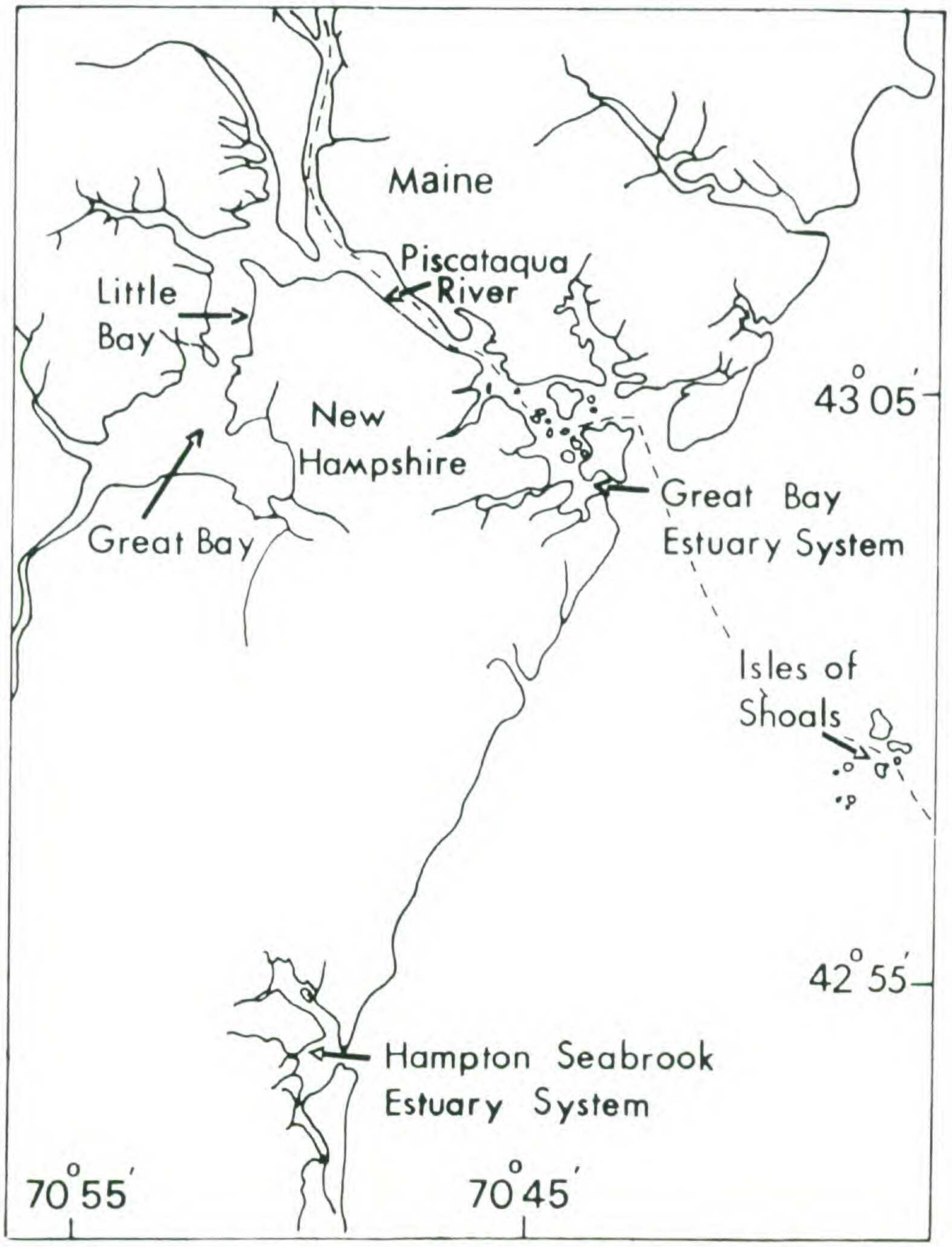

Figure 1. The New Hampshire coastal zone

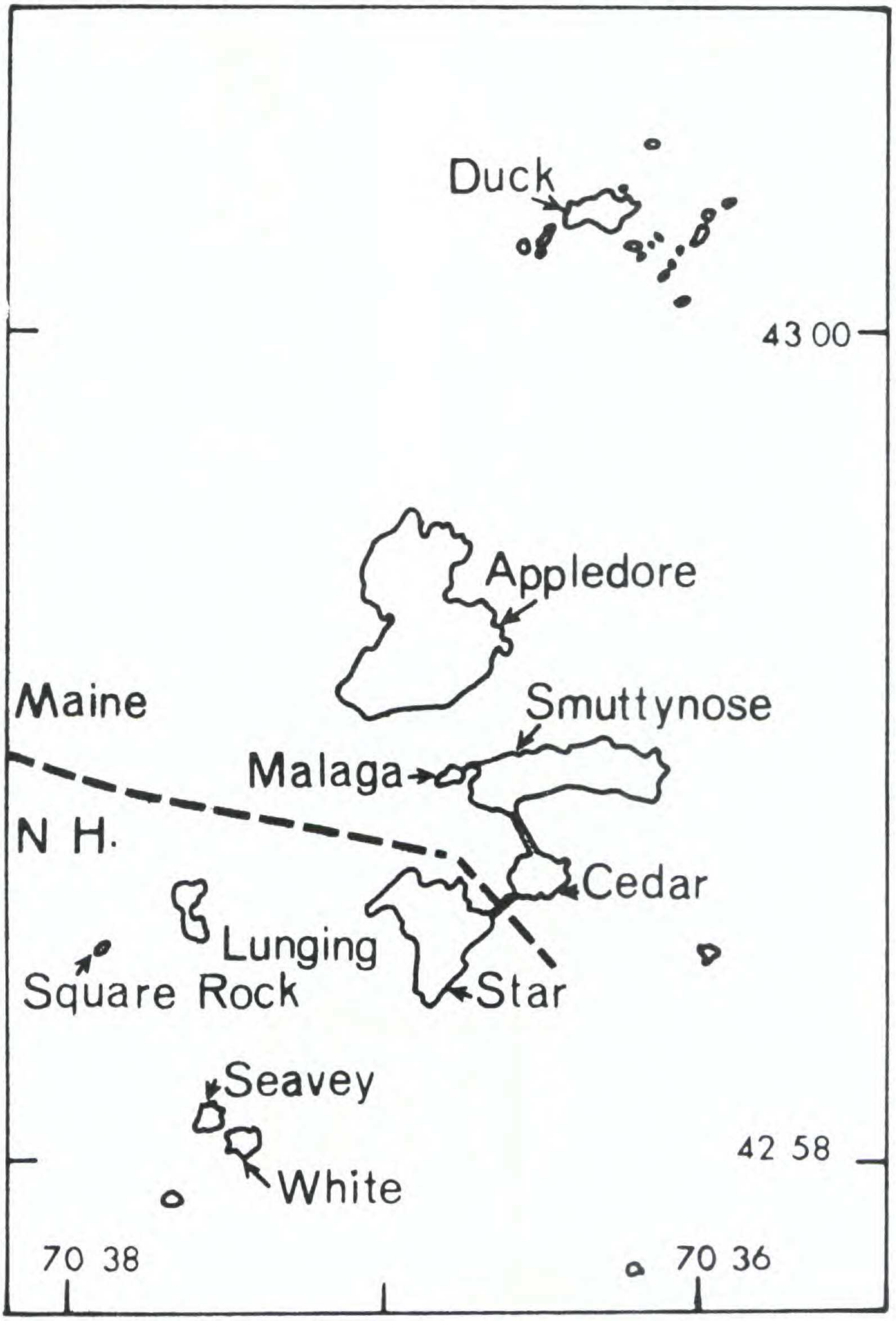

Figure 2. The Isles of Shoals, New Hampshire — Maine

found in July and August (43 and 40 taxa, respectively). A few fresh-water green algae (*Microspora, Oedogonium, Spirogyra* and *Stigeoclonium* spp.) were collected intermittently throughout the year and primarily in riverine or innermost estuarine habitats.

Forty-eight (83%) of the green algae recorded were considered to be annuals, while only 7 taxa (12%) were interpreted as perennials (Fig. 3). The longevity designations for *Cladophora sericea, Derbesia marina,* and *Ulva lactuca* require further study, as they may be either aseasonal annuals or pseudoperennials (*sensu* Knight & Parke, 1931). Specific details on the longevity and seasonal occurence of each taxa are summarized in Table I, as well as in the following annotated checklist.

A summary of the local distribution of chlorophycean taxa in the four major coastal-estuarine areas in New Hampshire (Figs. 1 and 2) is also shown in Figure 3. The highest number of species was recorded from the near-shore open coast between Portsmouth and Seabrook (i.e. 47 taxa). The species diversity within the Great Bay System and at the Isles of Shoals were very similar (i.e. 46 and 42 taxa, respectively). In contrast to the similarity of species richness at the three areas, their species compositions were quite different (Table I). For example, the fresh-water green algae mentioned earlier were only collected within riverine (i.e. innermost estuarine) habitats of the Great Bay Estuary System, and they were absent at both open coastal sites. The low species diversity (i.e. 18 taxa) within the Hampton-Seabrook Estuary System contrasts strongly with that of the Great Bay Estuary System.

ANNOTATED CHECKLIST

Fifty-eight taxa of chlorophycean algae are recorded in the following checklist from coastal and estuarine environments within the state. Twelve of these plants are newly recorded from New Hampshire: *Acrochaete repens, Bolbocoleon piliferum, Chlorochytrium moorei, Cladophora albida, C. pygmaea, C. rupestris, Enteromorpha flexuosa* ssp. *flexuosa, Gomontia polyrhiza, Monostroma leptodermum, Prasinocladus marinus, Pringsheimiella scutata* and *Stichococcus marinus*. None of the above taxa represent range extensions on the northeast coast of North America. The new records are indicated by asterisks in the list.

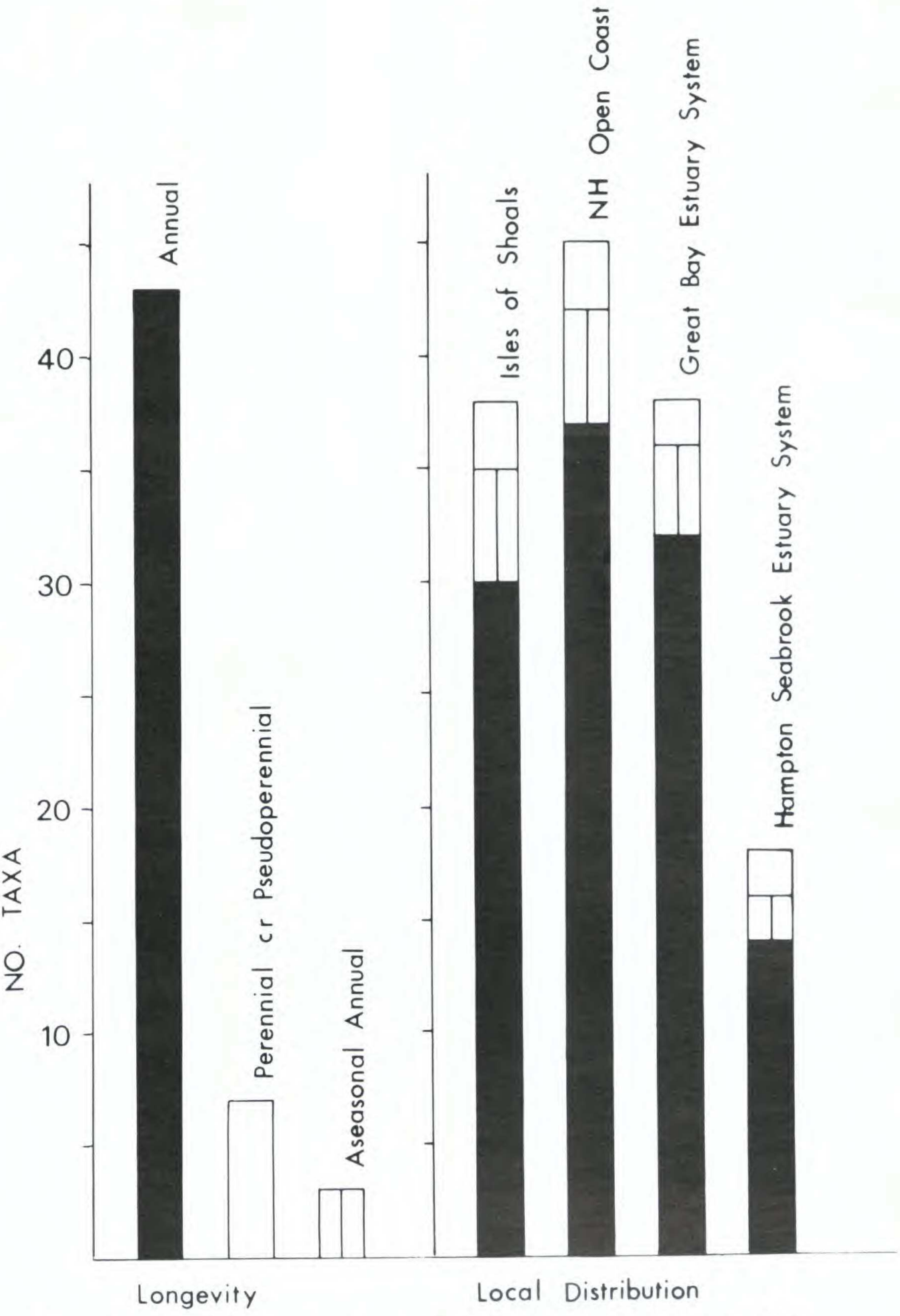

Figure 3. The longevity and local distribution of chlorophycean taxa in New Hampshire

Table 1: **Seasonal Occurrence, Longevity, and Local Distribution of Chlorophyceae**

TAXA	MONTHS												
	J	F	M	A	M	J	J	A	S	O	N	D	
Acrochaete repens			X*				X*						Ann. 2*,4*
Acrochaete viridis	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. 1,2,4
Blidingia minima	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. 1–4
Bolbocoleon piliferum			X*				X*						Ann. 2*
Bryopsis plumosa		X**				X	X	X	X	X	X	X	Ann. 1–4
Capsosiphon fulvescens			X*		X	X	X	X	X	X	X		Ann. 2,4
Chaetomorpha aerea	X	X	X	X	X	X	X	X	X	X	X	X	Per. 1,2,4
Chaetomorpha brachygona	X		X		X	X	X	X	X	X	X	X	Ann. (?) 1,2,4
Chaetomorpha linum	X	X	X	X	X	X	X	X	X	X	X	X	Per. 1–4
Chaetomorpha melagonium	X	X	X	X	X	X	X	X	X	X	X	X	Per. 1,2,4
Chaetomorpha minima										X	X		Ann. (?) 1
Chaetomorpha picquotiana	X	X	X	X	X	X	X	X	X	X	X	X	Per. 1–4
Chlorochytrium moorei										X			Ann. 2
Cladophora albida		X	X	X		X	X	X				X	AAnn. 1,2,4
Cladophora pygmaea	X	X	X	X	X	X	X	X	X	X			Per. 4
Cladophora refracta							X	X		X			Ann. 1,4
Cladophora rupestris		X				X		X		X			Per. 1
Cladophora sericea	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. or PPer. 1–4
Codiolum gregarium							X*	X			X		Ann. 2,4
Codiolum petrocelidis			X					X					Ann. 1,2
Codiolum pusillum		X				X	X	X	X	X	X	X	Ann. 1,2,4*

Derbesia marina				X	X						X		AAnn. or PPer. 1,2
Enteromorpha clathrata				X		X	X	X	X	X	X	X	Ann. 1–4
Enteromorpha compressa	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. 1–4
Enteromorpha flexuosa ssp. *flexuosa*							X		X	X			Ann. 4
Enteromorpha flexuosa ssp. *paradoxa*		X		X			X	X	X	X	X	X	Ann. 1–4
Enteromorpha intestinalis	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. 1–4
Enteromorpha linza	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. 1–4
Enteromorpha prolifera	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. 1–4
Enteromorpha torta				X			X	X	X			X	Ann. 2,4
Entocladia flustrae		X		X		X							Ann. (?) 1,2
Gomontia polyrhiza			X					X					Ann. (?) 1,2
Halicystis ovalis							X						Per. (?) 2
Microspora pachyderma	X	X	X	X	X	X*	X*			X	X*		Ann. 2*,4
Monostroma fuscum	X	X	X	X	X	X	X	X	X	X	X	X	Ann. 1–4
Monostroma grevillei	X	X	X	X	X	X				X	X	X	Ann. 1–4
Monostroma leptodermum					X	X	X	X	X				AAnn. 2–4
Monostroma oxyspermum	X	X	X	X	X	X	X	X	X	X	X	X	Ann. 1–4
Monostroma pulchrum			X	X	X	X							Ann. 1,2,4
Mougeotia sp.							X						Ann. 4
Oedogonium sp.								X	X				Ann. 4
Percursaria percursa		X	X	X	X	X	X	X	X	X	X		AAnn. 1–4
Prasinocladus marinus							X*						Ann. 2*

Table 1 (cont.)

TAXA	MONTH												
	J	F	M	A	M	J	J	A	S	O	N	D	
Prasiola stipitata	X	X	X	X	X	X	X	X	X	X	X		AAnn. 1,2,4
Pringsheimiella scutata			X							X			Ann. (?) 1
Pseudendoclonium submarinum							X	X			X		AAnn. 1,4
Rhizoclonium riparium	X	X	X	X	X	X	X	X	X	X	X		AAnn. 1–4
Rhizoclonium tortuosum	X	X	X	X	X	X	X	X	X	X	X		AAnn. (?) 1,2,4
Spirogyra sp.							X						Ann. 4
Spongomorpha arcta		X	X	X	X	X	X	X	X	X	X	X	Ann. 1,2,4
Spongomorpha spinescens				X	X	X	X	X		X	X	X	Ann. 1,2,4
Stichococcus marinus						X							Ann. 1
Stigeoclonium sp.			X										Ann. 4
Ulothrix flacca	X	X	X	X	X	X		X			X	X	Ann. 1,2,4
Ulva lactuca	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. or PPer. 1–4
Urospora penicilliformis	X	X	X	X	X	X	X	X		X	X	X	Ann. 1,2,4
Urospora speciosa		X	X	X	X								Ann. 1,2,4
Urospora wormskioldii	X	X	X	X	X		X	X*				X	Ann. 1,2,4
	24	32	36	34	32	36	43	40	30	36	34	27	

KEY TO TABLE I

x = presence
* = obtained in culture
** = residual basal material

Longevity:
- Ann. = annual
- AAnn. = aseasonal annual
- Per. = perennial
- PPer. = pseudoperennial *sensu* Knight & Parke (1931)

Local Distribution:
- 1 = Isles of Shoals
- 2 = Near-shore open coast
- 3 = Hampton-Seabrook Estuary System
- 4 = Great Bay Estuary System

***Acrochaete repens** N. Pringsheim

Obtained in cultures from open coastal and estuarine water samples (March and July), which were concentrated on glass fiber filters and grown in enriched seawater media (12–32 0/00) at 6–20C (R. Zechman, personal comm.). No *in situ* populations seen. Annual.

Acrochaete viridis (Reinke) R. Nielsen

Common on the open coast, less abundant and scattered within the Great Bay Estuary System. Endophytic within several fleshy red algae (0 to –8m), often turning them green. Nielsen (1979) transferred the type species of *Entocladia* Reinke to *Acrochaete* based upon culture studies of materials from the type locality. Aseasonal annual.

Blidingia minima (Nageli *ex* Kützing) Kylin

A common "opportunitistic" species (see Prange, 1978) at diverse open coastal and estuarine sites. Growing on a variety of substrata (rock, wood, etc.). More abundant and exhibiting a broader zonation in estuarine (+1.0 to +2.3m) than open coastal areas (+2.0 to +2.5m). Plants found in riverine (i.e. innermost estuarine) sites are morphologically variable and should be designated as variety *subsalsa* (Kjellman) Scagel, while the unbranched coastal plants are referrable to variety *minima* (see Abbott & Hollenberg, 1976; Scagel, 1966). Norris (1971) suggests that *Blidingia marginata* may be a juvenile stage of *B. minima*: we agree and have not differentiated it here. Aseasonal annual.

***Bolbocoleon piliferum** N. Pringsheim

Obtained in cultures from open coastal water samples (March and July), which were concentrated on glass fiber filters and grown in enriched sea water (12–32 0/00) at 6–20C (R. Zechman, personal comm.). None of the cultured plants occurred as endophytes or epiphytes, although a variety of "host" plants were present in the same cultures. No *in situ* populations seen. Annual.

Bryopsis plumosa (Hudson) C. Agardh

Common in shallow estuarine areas, rare on the open coast. Found on rocks, shells and coarse algae (0.0 to −10m). Abundant

during the summer and with some residual plants occasionally found during the fall-winter. Annual.

Capsosiphon fulvescens (C. Agardh) Setchell *et* Gardner

Occasional, found on a variety of substrata (+2.2 to +2.7m) in riverine or innermost estuarine habitats — often at the head-waters of tidal streams. Rare on the open coast, found growing in marshy ponds or pools, mixed with *Enteromorpha* spp., *Cladophora sericea*, and *Rhizoclonium riparium*. Collected from May-November. Annual.

Chaetomorpha aerea (Dillwyn) Kützing

Common on the open coast and collected at one outer estuarine site on the Piscataqua River. Found on rocks and ledges (+1.0 to +1.8 m), usually in tide pools. Often epiphytized by *Monostroma* spp., *Protectocarpus speciosus*, diatoms and other algae. Blair, et al. (1982) give a detailed account of the taxon as well as its differentiation from *C. linum*. Perennial.

Chaetomorpha brachygona Harvey

Occasional at several open coastal sites and scattered within the Great Bay Estuary System. Often mixed with other unbranched cladophoralean algae (+0.6 to −18.0m). Blair (1983) gives a detailed account of the taxon, as well as its differentiation from *Chaetomorpha cannabina* and *C. capillaris*. Annual (?).

Chaetomorpha linum (O. F. Müller) Kützing

Common in open coastal and estuarine environments; found detached and entangled amongst coarse seaweeds, including *Chaetomorpha picquotiana* (+0.6 to −20.0m). Occasionally found attached (i.e. initially) by a single basal cell (Blair, 1983). More common than *C. picquotiana* in estuarine areas, where it often forms extensive festoons 3–5 m long in tidal rapids (Reynolds, 1971). Perennial.

Chaetomorpha melagonium (Weber *et* Mohr) Kützing

Common on the open coast; rare within the Great Bay Estuary System where it often occurs as single filaments versus clumps of filaments on the open coast (Reynolds & Mathieson, 1975). Found on rocky substrata (+0.6 to −26.0m), often in tide pools. Rare in estuarine sites. Perennial.

Chaetomorpha minima Collins *et* Hervey

Found a few times at the Isles of Shoals during October and November; growing attached by a basal cell to *Chaetomorpha aerea* and *C. melagonium* (0.0 to +1.0m). Blair (1983) characterizes the taxon and discusses its possible interrelationships with *Rhizoclonium riparium*. Annual (?).

Chaetomorpha picquotiana (Montagne) Kützing

Common on the open coast, occasional and scattered in estuarine sites (Blair, 1983). Forming entangled masses amongst coarse seaweeds (+0.6 to −20.0m), including *Chaetomorpha linum*. Blair (1983) gives a recent interpretation of this taxon which has previously been referred to as *C. atrovirens* (Taylor, 1962).

***Chlorochytrium moorei** Gardner

Found once (October) growing within the mucilaginous sheath of the colonial diatom *Berkeleya rutilans*. Present in a high (+2.0m) marshy tide pool on the open coast. Annual.

***Cladophora albida** (Hudson) Kützing

Occasional at scattered open coastal and estuarine sites. Epilithic or epiphytic on coarse algae (0.0 to −3.0m). Present year-round. Aseasonal annual.

***Cladophora pygmaea** Reinke

Occasional at scattered sites within the Great Bay Estuary System. Found on rocks in association with a variety of encrusting taxa (e.g. *Pseudolithoderma extensum, Hildenbrandia rubra, Rhodophysema elegans, Ralfsia* spp.) within the sublittoral zone (0 to −10m). The plant may have been missed on the open coast because of its small size and dark green color (see South & Hooper, 1980; Wilce, 1970). Perennial.

Cladophora refracta (Roth) Kützing

Occasional on rocks at the Isles of Shoals (+2.0 to +2.5m), sometimes in tide pools. Found once within the mid-eulittoral zone within the Great Bay Estuary System. Annual.

***Cladophora rupestris** (Linnaeus) Kützing

Occasional on rocks at the Isles of Shoals (0.0 to −1.0 m) — often in

tide pools. Reported by Collins (Hoek, 1981) from Hampton, near the southern border of the near-shore open coast of New Hampshire. To date we have only collected the plant from the near-shore open coast in Massachusetts and Maine. Perennial (?).

Cladophora sericea (Hudson) Kützing

Common at diverse open coastal and estuarine sites. Growing on a wide variety of substrata (+2.6 to −6.0m). An aseasonal annual or a pseudoperennial (Knight & Parke, 1931) which is capable of regenerating upright filaments from basal, residual filaments.

Codiolum gregarium A. Braun

Occasional on the open coast and at the mouth of the Great Bay Estuary System. Also obtained in culture from estuarine water samples (July), which were concentrated on glass fiber filters and grown in enriched seawater media (12–32 0/00) at 6–20C (R. Zechman, personal comm.). The *in situ* collections were found on rocks within the splash zone (+2.0 to +3.4m) of the open coast, often mixed with a variety of blue-green algae (*Calothrix scopulorum, Lyngbya* and *Oscillatoria* spp.). The morphology of *Codiolum gregarium* is only slightly different from *C. pusillum* (Hanic, 1965), and both of these plants represent stages in the life histories of *Urospora* spp. and other green algae (Kornmann, 1959; Kornmann & Sahling, 1977; Scagel, 1966). Annual.

Codiolum petrocelidis Kuckuck

Occasional on the open coast, endophytic within *Petrocelis middendorfii* (0.0 to −8.0m). The plant is described as the "sporophyte" generation of *Spongomorpha spinescens* (Jonsson, 1958; Scagel, 1966). Annual.

Codiolum pusillum (Lyngbye) Kjellman

Common on the open coast. Also obtained in culture from estuarine water samples (July), which were concentrated on glass fiber filters and grown in enriched seawater media (12–32 0/00) at 6–20C (R. Zechman, personal comm.). The *in situ* collections were found on high rocks (+2.0 to +3.4m) during the summer and fall; often mixed with *Calothrix scopulorum, Urospora* spp., *Ulothrix flacca,* and *Bangia atropurpurea*. As noted previously, the plant is very similar morphologically to *C. gregarium*; both plants represent

stages in the life history of *Urospora* spp. (Hanic, 1965; Kornmann & Sahling, 1977; Scagel, 1966) and other green algae. Annual.

Derbesia marina (Lyngbye) Solier

Occasional on the open coast. Found on rocks (often sponge covered) within the sublittoral zone (0 to −15m). The plant represents the sporophytic stage in a pleomorphic (specialized heteromorphic) life history involving gametophytic *Halicystis ovalis* (Sears & Wilce, 1970). The vesicular stage of New England material has only been obtained in culture from Massachusetts plants (Sears, 1971) and from natural populations in New Hampshire (Mathieson & Burns, 1970). An aseasonal annual or a pseudoperennial, which is capable of regenerating from residual materials in sponge tissue (Sears, 1971).

Enteromorpha clathrata (Roth) Greville

Abundant in estuarine areas, entangled amongst coarse plants or attached to a variety of substrata (+1.0 to +2.0m). Less abundant on the open coast, occurring in high tide pools (+2.0 to +2.7m) mixed with *Enteromorpha* spp., *Cladophora sericea*, and *Rhizoclonium riparium*. Collected from April-December. Aseasonal annual.

Enteromorpha compressa (Linnaeus) Greville

Abundant at several widely distributed estuarine sites; less common on the open coast. Growing on rocks, occasionally epiphytic (+1.5 to +2.5m). As noted by DeSilva and Burrows (1973) the plant is extremely variable morphologically. Present year-round. Aseasonal annual.

***Enteromorpha flexuosa** (Wulfen *ex* Roth) J. Agardh
subsp. **flexuosa** Bliding

Uncommon at a few sites within the Great Bay Estuary System. Exposed to considerable fresh water. Found on rocks and entangled amongst coarse algae (+2.5m). Annual.

Enteromorpha flexuosa (Wulfen *ex* Roth) J. Agardh subsp. **paradoxa** (Dillwyn) Bliding

Occasional, found attached and entangled in high marshy tide pools (+2.2 to +2.7m) on the open coast, often mixed with *Entero-*

morpha clathrata, Cladophora sericea and *Rhizoclonium riparium*. More abundant in estuarine than coastal areas, particularly in high marshy pannes in the former areas. Primarily collected during the summer and fall. Annual.

Enteromorpha intestinalis (Linnaeus) Link

Abundant, found on a variety of substrata (0.0 to +2.5m). Present in tide pools and in disturbed surfaces (see Daly & Mathieson, 1977) on the open coast, as well as widely distributed in estuarine and riverine locales. Present year-round. Aseaonsal annual.

Enteromorpha linza (Linnaeus) J. Agardh

Common on the open coast, occasional and widely distributed in estuarine sites. Found on a variety of solid substrata, as well as epiphytic on coarse algae (+0.5 to −12.0m). Present year-round. Aseasonal annual.

Enteromorpha prolifera (O. F. Müller) J. Agardh

Occasional on the open coast; found on a variety of substrata, as well as entangled in high marshy areas (+1.0 to +2.7m). Ubiquitous in estuarine and riverine areas, again on a variety of substrata (+1.0 to 2.0m). Extremely variable morphologically, and often mixed with a variety of other *Enteromorpha* species. Present year-round. Aseasonal annual.

Enteromorpha torta (Mertens *in* Jurgens) Reinbold

Occasional in outer estuarine sites within the Great Bay Estuary System and on the adjacent open coast. Found on rocks and entangled amongst coarse algae (+1.5 to +3.0m). Mixed with other *Enteromorpha* spp., *Cladophora sericea*, and *Rhizoclonium riparium*. According to Nienhuis (1969) the morphological plasticity of *E. prolifera* may overlap with *E. torta* and the taxonomic difference between the two may not always be clear. Annual.

Entocladia flustrae (Reinke) Batters

Common on the open coast. Growing on the chitinous skeletons (i.e. hydrotheca) of *Sertularia* sp. (−0.3 to +2.2m) — often on vertical rock faces. Although only collected occasionally, it can probably be collected whenever it is specifically looked for (cf South & Hooper, 1980). Annual.

***Gomontia polyrhiza** (Lagerhiem) Bornet *et* Flahault

Uncommon, found twice (March and August) within mollusk shells on the open coast (0.0 to +2.0m). Probably more common than our collections indicate. The plant is described as the sporophytic generation of *Monostroma grevillei* (Kornmann, 1959). Annual (?).

Halicystis ovalis (Lyngbye) Areschoug

Uncommon, found twice during July at a single open coastal site; this is the only *in situ* collection of the plant on the northeast coast of North America (Mathieson & Burns, 1970). The vesicular thallus, which is the gametophytic stage in the life history of *Derbesia marina* (Sears & Wilce, 1970), is found attached to a variety of crustose coralline algae (e.g. *Clathromorphum circumscriptum, Lithothamnium glaciale,* and *Phymatolithon lenormandii*), on large rocks and boulders that are relatively free of sand or silt (−12 to −24m). According to Scagel (1966) new vesicles can be regenerated on successive years from the residual rhizomes. Perennial.

Microspora pachyderma (Wille) Lagerheim

Common on rocks at the head-waters of tidal tributaries (i.e. riverine sites) and occasionally found in more estuarine areas during spring thaw. The plant has also been extensively obtained in estuarine and open coastal water samples (June, July and November) which were concentrated on glass fiber filters and grown in enriched sea water (12–32 0/00) at 6–20C (R. Zechman, personal comm.). A fresh-water green alga that has tentatively been identified as *M. pachyderma*, although it has not been identified previously from estuarine habitats (Collins, 1912; Prescott, 1962). Found mixed with *Cladophora sericea* and *Blidingia minima* var. *subsalsa* (+1.5 to +2.0m) during January to May, and with a single *in situ* collection obtained in October. Annual.

Monostroma fuscum (Postels *et* Ruprecht) Wittrock

Common at a variety of open coastal and estuarine sites. Growing on rocks and epiphytic on coarse algae (+0.45 to −24.0m), often in tide pools. Present year-round and probably represented by several isomorphic sporophytic and gametophytic generations (Dube, 1967). Annual.

Monostroma grevillei (Thuret) Wittrock

Common at a variety of open coastal and estuarine sites; less abundant in the latter than the former areas. Found on rocks, mussels and as an epiphyte on coarse algae (+1.7 to −6.0m). First occurs as a saccate stage during the fall. Abundantly reproductive in May and June and absent during July-September. The interrelationship between *Gomontia polyrhiza* and *Monostroma grevillei* has been previously noted (see Kornmann, 1959). Annual.

***Monostroma leptodermum** Kjellman

Abundant at outer estuarine sites — rare on the open coast. Usually epiphytic on *Zostera marina* (0.0 to −1.0m). Found from May to September. Annual.

Monostroma oxyspermum (Kützing) Doty

Common in estuarine areas and tolerant to pronounced salinity variations. Rare and only collected a few times on the open coast —particularly after a very warm summer. Found on wood as well as as epilithic and epiphytic (+1.0 to +2.5m). Most abundant during the summer but some residual populations survive periods of winter ice coverage. Annual.

Monostroma pulchrum Farlow

Common in open coastal and outer estuarine areas within the Great Bay Estuary System. Epiphytic on coarse algae (+1.0 to −1.3m). Collected during March-June, with reproductive plants abundant during May and June. Annual.

Mougeotia sp.

Collected once (July) on rocks at the head-waters of the tidal limits of the Oyster River (+1.5 to +2.0m). A fresh-water green alga, found mixed with *Spirogyra* sp., *Cladophora sericea, Enteromorpha prolifera* and *Blidingia minima* var. *subsalsa*. Annual.

Oedogonium sp.

Collected twice (August and September) on rocks beneath a waterfall at the head-waters of the tidal limits of the Oyster River (+2.0m). A fresh-water green alga, found mixed with *Cladophora sericea, Enteromorpha prolifera* and *Blidingia minima* var. *subsalsa*. Annual.

Percursaria percursa (C. Agardh) Rosenvinge

Common in estuarine areas, occasional on the open coast (+2.0 to +2.7m). Growing amongst emergent halophytic plants in estuarine areas, mixed with *Enteromorpha* spp., *Cladophora sericea*, and *Rhizoclonium riparium*. Found in high marshy tide pools on the open coast, mixed with similar green algae as in estuarine areas. Most abundant during the summer, but present year-round. Annual.

***Prasinocladus marinus** (Cienkowski) Waern

Obtained in cultures from open coastal water samples (July), which were concentrated on glass fiber filters and grown in enriched seawater media (32 0/00) at 6C (R. Zechman, personal comm.). The dichotomously branched colonial form was observed growing detached on the surface of the culture media. No *in situ* populations seen. Annual.

Prasiola stipitata Suhr *in* Jessen

Common on the open coast and at the mouth of the Great Bay Estuary System. Often forming a conspicuous green coating in crevices and pockets on high rock faces (+2.7 to +3.5m), often associated with bird droppings. Present year-round. Aseasonal annual.

***Pringsheimiella scutata** (Reinke) Marchewianka

Rare, found twice on the open coast (+0.5 to +1.5m), once epiphytic on *Chondrus crispus* another time on *Choreocolax polysiphoniae*. Annual (?).

Pseudendoclonium submarinum Wille

Occasional in open coastal and estuarine areas. Found on rocks and shells (+2.0 to −10.0m). Probably more abundant than our collections would indicate. Aseasonal annual (Sears, 1971).

Rhizoclonium riparium (Roth) Harvey

Common in estuarine locations (+1.5 to +2.7m) and high marshy tide-pools (+2.2 to +2.7m) on the open coast, mixed with *Cladophora sericea* and *Enteromorpha* spp. Most common during the summer, but present year-round. Nienhuis (1975) placed *R. implexum* (Dill.) Kutz. (=*R. kerneri*) in synonomy with *R. riparium* based on extensive field and culture studies. Aseasonal annual.

Rhizoclonium tortuosum Kützing

Common on the open coast and with scattered estuarine populations within the Great Bay Estuary System. Found entangled amongst coarse algae (+0.6 to −12.0m). Most abundant during the summer, but present year-round. Aseasonal annual (?). See Blair (1983) for a detailed account of the taxon.

Spirogyra sp.

Collected once (July) on rocks at the head-water of the tidal limits of the Oyster River (+1.5 to +2.0m). A fresh-water green alga, found mixed with *Mougeotia* sp., *Cladophora sericea, Enteromorpha prolifera* and *Blidingia minima* var. *subsalsa*. Annual.

Spongomorpha arcta (Dillwyn) Kützing

Common on the open coast and outer sites within the Great Bay Estuary System. Usually epilithic, occasionally epiphytic on coarse seaweeds or entangled amongst dense populations of *Mytilus edulis* on the open coast (+0.9 to −11.0m). Most abundant during the winter and spring, but present year-round. Lamb and Zimmerman (1964) suggest that the plant is a perennial or pseudo-perennial being represented by reduced or inconspicuous basal filaments from late summer to the end of winter. We have observed the prolonged occurrence of basal remnants but no regeneration of upright filaments. Thus, we interpret it as an annual. As noted by South (1976), the size of the plant is extremely variable and it may encompass *Spongomorpha sonderi* (=*S. lanosa*) in Taylor (1962).

Spongomorpha spinescens Kützing

Common on the open coast and with scattered outer estuarine populations within the Great Bay Estuary System. Epilithic and occasionally epiphytic on coarse algae (+0.9 to −11.0m), often in tide pools. First appears in spring (April) and persists through the fall. Annual.

***Stichococcus marinus** (Wille) Hazen

Collected at two sites on the open coast (Smuttynose and White Islands) during a single date in June. Epilithic in high tide pools (+3.5m), mixed with a variety of green algae. Annual.

Stigeoclonium sp.

Found once (March) on rocks at the head-waters of the tidal limits of the Squamscott (Exeter) River (+2.0 to +2.3m). A fresh-water green alga, found mixed with *Blidingia minima* var. *subsalsa*. Annual.

Ulothrix flacca (Dillwyn) Thuret *in* Le Jolis

Common at a variety of open coastal and estuarine sites. Found on rocks, wood, metal, fucoid algae, other coarse seaweeds and halophytic flowering plants (+0.8 to +2.8m). Primarily found during the winter and spring. Annual.

Ulva lactuca Linnaeus

Abundant at a variety of open coastal and estuarine sites. Epilithic and epiphytic on coarse algae (+0.9 to −24.0m). Present throughout the year. According to Scagel (1966) and Lamb & Zimmerman (1964) the holdfast of *Ulva* may be perennial; we have not seen regeneration of the blades from the holdfast. We interpret the plant as an aseasonal annual or a pseudo-perennial.

Urospora penicilliformis (Roth) Areschoug

Common on the open coast, occasional in outer estuarine sites within the Great Bay Estuary System. Found on a wide variety of substrata (+1.2 to +2.4 m). Although it is most abundant in the winter and spring, it has been collected each month, except September. Annual.

Urospora speciosa (Carmichael *ex* Harvey in Hooker) Le Blond *ex* Hamel

Uncommon on the open coast and within the Great Bay Estuary System. Epilithic and mixed with other *Urospora* spp., *Ulothrix flacca*, and *Bangia atropurpurea* (+2.5 to +2.8m). Collected during late winter and spring. Annual.

Urospora wormskioldii (Mertens *in* Hornemann) Rosenvinge

Common on the open coast and in outer estuarine sites within the Great Bay Estuary System. Found on a variety of rocky substrata (+1.2 to +2.4m), mixed with other *Urospora* spp., *Ulothrix flacca*, *Codiolum pusillum*, *Blidingia minima* var. *minima*, *Bangia atro-*

purpurea, and various blue green algae. *In situ* populations are abundant in the winter and spring (December-May), with a few residual populations found in the summer (July). The plant was also obtained in culture from open coastal water samples (August), which were concentrated on glass fiber filters and grown in enriched seawater media (12–32 0/00) at 6–20C (R. Zechman, personal comm.). Annual.

Discussion

The chlorophycean flora of New Hampshire is characterized by a large number of annuals (82%) and a seasonally variable cycle of species numbers with a winter minimum and a summer maximum. Similar phenological patterns have been noted in other North Atlantic areas (MacFarlane & Bell, 1933; Lamb & Zimmerman, 1964; Coleman & Mathieson, 1975; Reynolds & Mathieson, 1975; Sears & Wilce, 1975), particularly sites with pronounced temperature fluctuations (cf Chapman, 1964; Williams, 1948, 1949). The phaeophycean and rhodophycean taxa within the state (Hehre & Mathieson, 1970; Mathieson & Hehre, 1982) have more pronounced seasonal cycles and greater percentages of perennial taxa than the green algae.

An evaluation of Table I suggests that there are two primary groups of chlorophycean annuals: aseasonal and seasonal. The former plants reproduce throughout the year and are represented by successive populations (see Mathieson et al., 1981), while the latter plants have a more restricted reproductive phenology. Some chlorophycean annuals (e.g. *Bryopsis plumosa*) showed a pronounced seasonal cycle of occurrence and abundance; others, such as *Monostroma oxyspermum*, were most abundant during one season (summer) and represented by residual populations at other times. Previous studies on the red and brown algae within the state (Hehre & Mathieson, 1970; Mathieson & Hehre, 1982) demonstrate a similar characterization of annuals. Detailed tagging studies of *in situ* populations would help to clarify the longevity and demography of many green algae, particularly those designated as aseasonal annuals and pseudoperennials (Knight & Parke, 1931).

As noted earlier (Fig. 3), the highest number of species were recorded on the near-shore open coast (i.e. 47 taxa). The species diversity within the Great Bay Estuary System and at the Isles of

Shoals were very similar (i.e. 46 and 42 taxa, respectively), while the lowest numbers of taxa were evident within the Hampton-Seabrook Estuary System (18 taxa). The high species diversity at the near-shore sites and the Great Bay Estuary System is probably associated with a greater variety of habitats and area than at the Isles of Shoals. Even so the Isles of Shoals represent a relatively "pristine" set of small islands with a very diverse chlorophycean flora. Overall, the near-shore open coast has a greater number of "estuarine" species than the Isles of Shoals. The species composition within the Great Bay Estuary System is very different than that at the Isles of Shoals, because of the presence of several fresh-water green algae, the enhanced number of estuarine taxa, and the reduced number of "open coastal" species (Table I). Even so, the presence of strong tidal rapids allows some "open coastal" forms to colonize estuarine areas like Dover Point (Reynolds, 1971; Reynolds & Mathieson, 1975). The differences in species diversity between the Great Bay and Hampton-Seabrook Estuary Systems may also be explained by a greater diversity of habitats, area, and substrata within the former estuary system.

In addition to the taxa listed earlier, three other green algae are recorded from the Isles of Shoals in an unpublished checklist (Anon., 1975): *Bryopsis hypnoides*?, *Rhizoclonium erectum*, and *Ulothrix laetevirens*. We have neither collected these plants nor seen voucher materials of these taxa; hence they are not included in the present synopsis.

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